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Project/Task OU 10-05 Interim Action

Subtask Risk Analysis for Soil Contaminants

EDF Page ___ of ___

Subject: **Risk Analysis for Determination of Risk-based Soil Screening Concentrations for Potential Explosive Residues at Ordnance Areas (OU 10-05) at the Idaho National Engineering Laboratory**

Abstract:

A risk analysis was performed by EG&G Idaho, Inc. to support the Record of Decision (ROD) for interim action of Operable Unit (OU) 10-05 at the Idaho National Engineering Laboratory. The purpose of the risk analysis is to identify soil concentrations that would fall within the National Contingency Plan target risk range of 10^{-4} and 10^{-6}. The action levels for soil cleanup and cleanup standard would then be selected and documented in the final ROD for the interim action of OU 10-05 based on information from the risk analysis and documented work at other ordnance sites.

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Author	Dept.	Reviewed	Date	Approved	Date
M. Figueroa	7830	W. J. Isle	2/28/92	L. V. Street	2/28/92

M. C. Figueroa 2/28/92

W. J. Isle 2/

L. V. Street

RISK ANALYSIS FOR DETERMINATION OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR POTENTIAL EXPLOSIVE RESIDUES AT ORDNANCE AREAS (OU 10-05) AT THE IDAHO NATIONAL ENGINEERING LABORATORY

I. del C. Figueroa

RISK ANALYSIS FOR DETERMINATION OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR POTENTIAL EXPLOSIVE RESIDUES AT ORDNANCE AREAS (OU 10-05) AT THE IDAHO NATIONAL ENGINEERING LABORATORY

1. INTRODUCTION

This report describes the derivation of risk-based soil screening concentrations for potential explosive residues associated with ordnance areas within Operable Unit (OU) 10-05 of Waste Area Group (WAG) 10. Unexploded ordnance devices and soil contaminated with explosive residues have been identified at the Idaho National Engineering Laboratory (INEL). The ordnance are primarily the result of World War II era activities associated with the former Naval Proving Ground, prior to inception of the INEL.

An interim action, or cleanup, has been proposed to reduce or eliminate potential hazards and risks from unexploded ordnance and explosive residues at OU 10-05. To ensure protection of human health, risk-based soil screening concentrations were calculated to serve as guidance for the cleanup of soils at the ordnance areas. The risk analysis followed the protocol in *Track-1 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL.*[1] Risk-based soil concentrations were calculated for potential explosive residues originating from ordnance historically detonated or disposed at the INEL.

2. METHODOLOGY

A qualitative risk assessment was performed to derive risk-based soil screening concentrations for explosives and related compounds associated with the ordnance areas at the INEL. In general, the evaluation followed the risk assessment screening methodology of the track-1 guidance document (see Reference 1), with some modifications. Modifications included the evaluation of an additional pathway of exposure (dermal contact) and the derivation of

toxicity data. These modifications will be explained in detail in the following sections.

The track-1 guidance document is conservative and uses humans as sensitive indicators for the environment. The methodology focuses on major environmental pathways, receptors, and exposure scenarios to identify risk-based soil criteria for contaminants of concern.

The objective of the track-1 evaluation is to determine the soil concentration that represents an acceptable risk. Risk-based soil concentrations are back-calculated from established EPA risk criteria. Because the purpose is to obtain the risk-based soil concentration, the track-1 methodology does not requires sampling data. Instead, the procedure uses risk criteria to establish the acceptable concentration in the media of concern.

2.1 Contaminants of Concern

The potential contaminants of concern evaluated included: 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 1,3-dinitrobenzene (1,3-DNB), 1,2-dinitrobenzene (1,2-DNB), 1,4-dinitrobenzene (1,4-DNB), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and 1,3,5-trinitrobenzene (1,3,5-TNB). The contaminants of concern chosen for this evaluation represent constituents of explosive residues from ordnance historically detonated or disposed at the INEL.

2.2 Exposure Scenarios and Pathways

The selection of exposure scenarios was based on the track-1 guidance. The track-1 methodology is conservative and is based on hypothetical scenarios of exposure. Both present and future hypothetical exposures were considered in the determination of soil screening concentrations. Two exposure scenarios were evaluated: occupational and residential. The occupational scenario evaluates a hypothetical worker at the site who is assumed to be exposed to the contaminants in the soil. The residential scenario considers exposures to

hypothetical individuals that are assumed to reside at the site under conditions that would exist in 100 years. The residential scenario was developed based on the assumption of institutional control at the INEL for a period of 100 years.

The track-1 evaluation considers four main pathways of exposure: soil ingestion, inhalation of fugitive dust, inhalation of volatiles, and groundwater ingestion. Inhalation of volatiles was not included in this evaluation because none of the contaminants are considered volatile based on the track-1 guidance criteria. Groundwater ingestion was not considered in this evaluation because contamination is expected to occur only in the surface soils. Also, there is no evidence of migration of ordnance contaminants to subsurface soils. In addition to the track-1 pathways, dermal contact was also evaluated based on the potential dermal hazards posed by the contaminants of concern.

Very conservative exposure parameters and assumptions were used to estimate the risk-based soil concentrations (see Table 1). Exposure parameters and assumptions for ingestion of soil and inhalation of fugitive dust followed EPA guidance and were obtained from the track-1 guidance document. Exposure parameters for the dermal contact pathway were based on EPA Region 10 guidance.[2]

Table 1. Summary of exposure parameters used in the calculation of risk-based soil screening concentrations for ordnance areas.

Exposure Scenario	Exposure Pathway	Intake rate	Exposure Frequency (d/y)	Exposure Duration (y)	Body Weight (kg)
Occupational	Inhalation of dust	20 m^3/d	250	25	70
	Ingestion of soil	50 mg/d	250	25	70
Residential	Inhalation of dust	20 m^3/d	350	30	70
	Ingestion of soil	200 mg/d (child) 100 mg/d (adult)	350	6 (child) 24 (adult)	15 (child) 70 (adult)

Exposure scenario	Exposure pathway	Body surface area (m^2/d)	Dermal Absorption[a]	Adherence factor (g/m^2)	Exposure Frequency (d/y)	Exposure Duration (y)	Body weight (kg)
Occupational	Dermal contact	0.30	0.68 (TNT and RDX) 0.80 (DNBs and DNTs)	19	0.36 x 365= 90	25	70
Residential	Dermal contact	0.30	0.68 (TNT and RDX) 0.80 (DNBs and DNTs)	19	0.14 x 365= 49	30	70

a. The dermal absorption factor is contaminant-specific (see text for explanation of dermal absorption factors used in this evaluation).

The track-1 guidance requires an area of contamination to perform the evaluation for the inhalation pathway. For this evaluation, the area of contamination was assumed to be 100 m^2 (length = 10 m, width = 10 m). The above assumption was based on the estimated potential area of contamination after the detonation of ordnance devices. It is important to realize that the other pathways of exposure (ingestion of soil and dermal contact) are not affected by the assumption of a fixed area. Only the inhalation calculation is dependent on the area of contamination.

2.3 Toxicity Assessment

Four of the above listed potential contaminants have been classified by the EPA as carcinogens. DNTs (2,4-DNT and 2,6-DNT) are classified as Group B2 carcinogens (probable human carcinogens; sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans). TNT and RDX are classified as Group C carcinogens (possible human carcinogens; limited evidence of carcinogenicity in animals and inadequate or lack of human data).

The derivation of soil screening levels involves the identification of toxicity values, which are then used in the determination of risk-based soil concentrations. A toxicity assessment was conducted to identify the noncarcinogenic and carcinogenic potential of the potential contaminants of concern at the ordnance areas. As suggested by the EPA, two main sources of information were examined for the identification of toxicity values: Integrated Risk Information System (IRIS)[3] and Health Effects Assessment Summary Tables (HEAST).[4]

The toxicity values used to evaluate the potential for noncarcinogenic effects are referred to as reference doses (RfDs). Chronic RfDs were used in this evaluation; a chronic RfD is an estimate of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse effects during a lifetime. The toxicity values used to evaluate the potential for carcinogenic effects are referred to as

slope factors (SFs). SFs represent an estimate of the upper-bound lifetime probability of an individual developing cancer per unit intake of a chemical.

Ingestion values used in the determination of risk-based concentrations, for most of the potential contaminants of concern, were obtained from IRIS or HEAST. The oral reference doses (RfDs) for DNTs were derived from animal data obtained from the Agency of Toxic Substances and Disease Registry (ATSDR).[5] A chronic no-adverse-effect-level (NOAEL), based on the oral intake of 2,4-DNT in dogs, was used to derive an ingestion RfD for 2,4-DNT for humans. The toxicity data indicated that the dog was the most sensitive species (lowest NOAEL). The NOAEL (0.2 mg/kg/d) was divided by an uncertainty factor (UF) of 100 (a factor of 10 to account for intraspecies extrapolation and a factor of 10 to protect sensitive individuals). A subchronic NOAEL for 2,6-DNT, 4 mg/kg/d based on a dog study, was used in the derivation of an oral RfD for 2,6-DNT. The toxicity data for 2,6-DNT indicated that the dog was the most sensitive species. The subchronic NOAEL was divided by an uncertainty factor of 1000 (a factor of 10 to account for the use of a subchronic value, a factor of 10 for intraspecies extrapolation, and a factor of 10 to protect sensitive individuals).

There are no EPA established toxicity values for the contaminants of concern for the inhalation route of exposure. Inhalation RfDs for all evaluated substances were derived from available occupational standards or limits[6] (see Table 2). The inhalation pathway was not evaluated for 1,3,5-trinitrobenzene because of the lack of toxicity data. The occupational exposure level (mg/m^3) obtained from Reference 6 was converted to an inhalation dose by multiplying by 20 mg/m^3 (assumed inhalation rate) and dividing by 70 kg (assumed body weight of an individual) (see Reference 2). The occupational exposure level was divided by an uncertainty factor of 100, as discussed below, to account for differences between exposure in an occupational setting and the conditions of exposure for the general population.

Table 2. Occupational exposure levels used in the derivation of inhalation toxicity values.

Chemical	Occupational exposure level (mg/m^3)[a]	Regulation or Guideline
TNT	5.0E-01	OSHA/NIOSH, PEL/REL[b]
2,4-DNT	1.5E+00	OSHA/NIOSH, PEL/REL[b]
2,6-DNT	1.5E+00	OSHA/NIOSH, PEL/REL[b]
1,3-DNB	1.0E+00	OSHA/NIOSH, PEL/REL[b]
1,2-DNB	1.0E+00	OSHA/NIOSH, PEL/REL[b]
1,4-DNB	1.0E+00	OSHA/NIOSH, PEL/REL[b]
RDX	1.5E+00	ACGIH, TLV[c]

a. Time weighted average for a 8-hr/day, 5-day workweek (see Reference 6).
b. Occupational Safety and Health Administration (OSHA) permissible exposure level (PEL) and National Institute of Occupational Safety and Health (NIOSH) recommended exposure limit (REL).
c. American Conference of Governmental Industrial Hygienist (ACGIH) threshold limit value (TLV).

Occupational exposure levels are intended to protect healthy workers between the ages of 18 and 65 from intermittent exposure to a chemical and are often based on acute effects. By contrast, the RfDs are intended to protect all members of the population against continuous chronic exposure (for a lifetime) to a chemical. To perform the assessment of potential inhalation exposure, the occupational exposure level was divided by an uncertainty factor of 100 (a factor of 10 to protect sensitive individuals and a factor of 10 to account for less than chronic exposure). It should be noted that there are fundamental differences between occupational exposure levels and RfDs in terms of methodology and intended use. The adjustment performed in the derivation of inhalation RfDs (division by UFs) might not overcome the differences between occupational levels and RfDs. The derived inhalation RfDs could represent underestimates or overestimates of acceptable inhalation exposure levels for the general population. The derived values should be viewed as estimates of inhalation exposure extrapolated from occupational limits and intended for screening purposes only. The derivation was performed using best professional judgement in order to be able to screen the inhalation pathway.

The dermal pathway was evaluated only for those contaminants for which data are available regarding dermal absorption or dermal effects. After reviewing available information, the following contaminants were identified as applicable to the dermal exposure evaluation, based on available data: DNBs (1,3-DNB, 1,2-DNB, and 1,4-DNB), DNTs (2,4-DNT and 2,6-DNT), TNT, and RDX. Data on the dermal effects of 1,3,5-TNB in animals or humans are lacking. Therefore, the dermal exposure pathway for 1,3,5-TNB was not evaluated.

There is available evidence of toxicity by skin absorption for TNT[7] and RDX.[8] Dermal toxicity values for TNT and RDX were derived from oral toxicity data following EPA guidance.[9] The following relationships were used to derive dermal toxicity values:

Dermal RfD = Oral RfD x Oral AE

Dermal SF = Oral SF / Oral AE

where

RfD	=	reference dose (mg/kg/d)
SF	=	slope factor $(mg/kg/d)^{-1}$
AE	=	absorption efficiency (%)

The above methodology follows EPA guidance (see Reference 9). Specific data on oral absorption efficiency, in the species on which the oral toxicity value is based, were used to adjust administered doses to absorbed doses. Dermal absorption data were then used to determine the dermal exposure to TNT and RDX. Chemical specific absorption data (oral and dermal) for TNT were obtained from Reference 7; oral absorption data for RDX were obtained from Reference 8. Due to the lack of specific dermal absorption data for RDX, the dermal absorption factor for TNT was also used in the evaluation of RDX. This approach should represent a reasonable estimate because the toxic hazards of RDX are considered comparable to the toxicity of TNT.[10] The oral and dermal absorption efficiencies used in the derivation of dermal toxicity values for TNT and RDX are shown in Table 3.

There are very limited data on the effects of dermal exposure to 2,4-DNT and 2,6-DNT. The two contaminants have been described as mild irritants in rabbits (see Reference 5). There is also some evidence of dermal absorption based on occupational exposure to DNTs; two studies have suggested that dermal absorption can be a significant route of entry for these isomers in humans (see Reference 5). The existing data are qualitative and there are no data available specifically on the dermal absorption of 2,4-DNT or 2,6-DNT. Due to the lack of quantitative absorption data, this evaluation relied on the estimation of dermal toxicity values from oral values to determine risk-based soil concentration based on the dermal exposure pathway. Dermal toxicity values were estimated using an oral absorption factor of 90% (highest absorption factor observed in animals) obtained from Reference 5. The estimation procedure was the same used for TNT and RDX (see paragraph above). An assumed dermal absorption factor of 80% was used to estimate dermal exposure to DNTs. The 80% value is the EPA Region 10 recommended absorption efficiency factor for organic compounds (see Reference 2). The absorption

data used in the derivation of dermal toxicity values for DNTs are shown in Table 3.

Table 3. Oral and dermal absorption data used in the derivation of dermal toxicity values for TNT, RDX and DNTs (2,4-DNT and 2,6-DNT).

Chemical	Oral absorption		Dermal absorption	
	Efficiency	Species	Efficiency	Species
TNT	70%[a]	dog	68%[d]	rabbit
	65%[b]	rat		
RDX	96%[c]	rat	68%[d]	rabbit
2,4-DNT	90%[e]	--	80%[f]	--
2,6-DNT	90%[e]	--	80%[f]	--

a. Oral absorption efficiency (dog) used in the derivation of the dermal RfD for TNT (see Reference 7); the dermal RfD was derived from the oral RfD, which is based on a dog study.
b. Oral absorption efficiency (rat) used in the derivation of the dermal SF for TNT (see Reference 7); the dermal SF was derived from the oral SF, which is based on a rat study.
c. Oral absorption efficiency (rat) used in the derivation of the dermal RfD and SF for RDX (see Reference 8). The dermal RfD was derived from the oral RfD, which is based on a rat study. The dermal SF was derived from the oral SF, which is based on a mouse study. Due to the lack of absorption data for mice, the absorption data for rats were used in the derivation of the dermal SF for RDX.
d. A dermal absorption efficiency of 68% for rabbits, based on TNT absorption (see Reference 7), was used in the calculation of dermal intake for both TNT and RDX; the rabbit was the most sensitive species and thus 68% represents a conservative value for dermal absorption of TNT. The TNT absorption value was also used for RDX because there were no available data on the dermal absorption of RDX.
e. Absorption value obtained from animal studies on rats, rabbits, dogs, and monkeys (see Reference 5); the highest absorption value (90%), based on the reported range (50 - 90%), was used in this evaluation.
f. Generic dermal absorption factor for organic compounds; obtained from EPA Region 10 (see Reference 2).

The DNBs were also evaluated for dermal exposure based on available toxicity data. A dermal TDLo (toxic dose low, the lowest dose reported to produce a toxic effect) for 1,3-DNB was obtained from the Registry of Toxic Effects of Chemical Substances (RTECS).[11] The available acute study provided evidence of systemic toxicity of 1,3-DNB following application onto the skin. The toxic dose (2 mg/kg/d) was divided by an uncertainty factor of 1000 (a factor of 10 to account for less than chronic exposure, a factor of 10 to account for using a TDLo value, and a factor of 10 to protect sensitive individuals) to obtain a dermal RfD. The derived RfD (2.0E-03 mg/kg/d) was also used in the evaluation of dermal exposure for the other two isomers of DNB (1,2-DNB and 1,4-DNB). This approach is reasonable because there is evidence of skin absorption for the three isomers of DNB; all three isomers are readily absorbed through the skin.[12] Also, systemic toxic effects are similar for all isomers of DNB. The evaluation of dermal exposure for DNBs assumed a dermal absorption factor of 80% (absorption efficiency for organic compounds recommended by EPA Region 10, see Reference 2).

Toxicity values (RfDs and SFs) used in the calculation of risk-based soil concentrations are shown in Table 4.

Table 4. Toxicity values used in the calculation of risk-based soil screening concentrations.

Chemical	RfD (mg/kg/d)			SF $(mg/kg/d)^{-1}$		
	Inhalation[a]	Ingestion (Oral)	Dermal	Inhalation	Ingestion (Oral)	Dermal
TNT	1.4E-03[a]	5.0E-04[b]	3.5E-04[e]	NA	3.0E-02[b]	4.6E-02[e]
2,4-DNT	4.3E-03[a]	2.0E-03[c]	1.8E-03[e]	NA	6.8E-01[b,g]	7.6E-01[e]
2,6-DNT	4.3E-03[a]	4.0E-03[c]	3.6E-03[e]	NA	6.8E-01[b,g]	7.6E-01[e]
1,3-DNB	2.9E-03[a]	1.0E-04[b]	2.0E-03[f]	NA	NA	NA
1,2-DNB	2.9E-03[a]	4.0E-04[d]	2.0E-03[f]	NA	NA	NA
1,4-DNB	2.9E-03[a]	4.0E-04[d]	2.0E-03[f]	NA	NA	NA
RDX	4.3E-03[a]	3.0E-03[b]	2.9E-03[e]	NA	1.1E-01[b]	1.1E-01[e]
1,3,5-TNB	NA	5.0E-05[b]	NA	NA	NA	NA

NA = No data available.
a. All inhalation RfDs were derived from occupational exposure levels and are intended for screening purposes only (see text for additional information).
b. Toxicity value obtained from IRIS (see Reference 3).
c. Toxicity value estimated from animal data (see text for explanation).
d. Toxicity value obtained from HEAST (see Reference 4).
e. Dermal toxicity value was derived from an oral toxicity value (see text for explanation).
f. Dermal toxicity value was derived from a TDLo (see text for explanation).
g. Toxicity value is for a mixture of 2,4- and 2,6-dinitrotoluene isomers.

3. CALCULATION OF RISK-BASED CONCENTRATIONS

The purpose of this evaluation was to calculate the soil concentration associated with a given acceptable risk for each contaminant of concern at the ordnance areas. This is referred to as the risk-based screening concentration.

For noncarcinogens, the concentration in the soil that would result in an intake equivalent to the chronic RfD or a hazard quotient of 1 is calculated. A concentration that represents a hazard quotient of 1 is considered protective against noncarcinogenic effects.

For carcinogens, the concentration in soil that would be equivalent to an incremental cancer risk of 1.0E-04 or 1.0E-06 is calculated. An incremental cancer risk between 1.0E-04 and 1.0E-06 is frequently the target level for remedial actions and is considered by the EPA as an acceptable range for cancer risks.

Standard EPA equations for exposure and risk assessment are used in the calculation of risk-based soil screening levels (see Reference 1). The equations include exposure parameters (i.e., intake rate, exposure frequency, exposure duration, body weight, etc.) applicable to the evaluated pathways and scenarios (see Table 1 for exposure parameters). Appropriate conversion factors are added to the equations to obtain the soil screening concentration based on acceptable risks. The equations used in the evaluation of soil ingestion and inhalation pathways are described in detail in Reference 1 (track-1 guidance document).

As explained earlier, in addition to the track-1 pathways, dermal contact exposure was also evaluated. The calculation of soil screening concentrations for dermal exposure followed EPA guidance (see Reference 9). Appropriate exposure parameters for dermal exposure are used in the calculation (see Table 1 for exposure parameters). The following relationships were used:

For noncarcinogens:

$$CS = \frac{THQ \times RfD \times BW \times AT \times CF}{BSA \times DA \times AF \times EF \times ED}$$

where

CS = risk-based soil concentration (mg/kg)
THQ = target hazard quotient (1)
RfD = chemical-specific reference dose (mg/kg/d)
BW = body weight (kg)
AT = averaging time (ED x 365 d/y for noncarcinogens)
CF = conversion factor (1000 g/kg)
BSA = body surface area available for contact per event (m^2/d)
DA = dermal absorption (contaminant-specific)
AF = adherence factor (g/m^2)
EF = exposure frequency (d/y)
ED = exposure duration (y)

For carcinogens:

$$CS = \frac{TR \times BW \times AT \times CF}{SF \times BSA \times DA \times AF \times EF \times ED}$$

where

CS = risk-based soil concentration (mg/kg)
TR = target excess individual lifetime cancer risk (1.0E-04 or 1.0E-06)
BW = body weight (kg)
AT = averaging time (70 y (lifetime) x 365 d/y for carcinogens)
CF = conversion factor (1000 g/kg)
SF = chemical-specific slope factor $(mg/kg/d)^{-1}$
BSA = body surface area available for contact per event (m^2/d)
DA = dermal absorption (contaminant-specific)
AF = adherence factor (g/m^2)
EF = exposure frequency (d/y)
ED = exposure duration (y)

4. RESULTS AND DISCUSSION

The risk-based concentrations for each potential contaminant and each pathway evaluated are shown in the Appendix. Soil screening levels were calculated for both occupational and residential scenarios following the track-1 guidance. For substances evaluated for carcinogenic effects, risk-based concentrations are shown for both 1.0E-04 and 1.0E-06 risk, representing the EPA range of acceptable risks for carcinogens. Risk-based soil concentrations for noncarcinogenic effects represent the acceptable level equivalent to a hazard quotient of 1. The resulting risk-based soil screening levels (lowest soil concentrations based on noncarcinogenic and carcinogenic effects) and the limiting exposure pathway for each contaminant evaluated are shown in Table 5.

Soil concentrations at the ordnance areas found to be equal or below the calculated screening levels shown in Table 5 are expected to be safe or acceptable, relative to noncarcinogenic or carcinogenic effects. Because the evaluation was based on very conservative exposure assumptions, the resulting screening levels should be protective against actual or expected exposures to the contaminants of concern.

The analysis showed that the soil ingestion pathway was the limiting exposure pathway for DNBs (1,3-DNB, 1,2-DNB, and 1,4-DNB) and 1,3,5-TNB. Soil ingestion was the most significant pathway of risk (lowest risk-based soil concentration) for DNBs and 1,3,5-TNB. The risk-based soil screening concentrations for these contaminants are based on EPA established toxicity values.

The lowest risk-based soil concentration for DNTs (2,4-DNT and 2,6-DNT), TNT and RDX are based on the dermal contact pathway. It should be noted that the calculation for dermal exposure was based on estimated toxicity values due to the lack of EPA established dermal data. The estimation procedure for deriving the values used in the assessment of dermal exposure was based on EPA guidance (see Reference 9). The estimation relied on assumptions for absorption efficiencies (oral and dermal) of the compounds evaluated for

dermal exposure. Conservative values for absorption were used in this evaluation, based on available data.

The inhalation pathway was not a significant pathway of exposure in comparison with soil ingestion or dermal contact. Risks from inhalation were three to six orders of magnitude lower than risks from soil ingestion or dermal contact. Inhalation toxicity values were estimated from occupational exposure levels to perform the assessment of potential inhalation exposure. Although the inhalation values were estimated, the calculations clearly indicate that inhalation is not an important route of exposure for the contaminants of concern.

Table 5. Summary of risk-based soil concentrations and limiting exposure pathways for potential ordnance contaminants based on a hazard quotient of 1 or a cancer risk range of 1.0E-04 to 1.0E-06.

Chemical	Risk-based Soil Concentration (mg/kg)			Exposure Pathway/ Scenario
	Hazard Quotient = 1	Cancer Risk Range		
		1.0E-04	1.0E-06	
TNT	2.6E+01[a]	4.4E+02[a]	4.4E+00[a]	Dermal Contact/ Occupational
2,4-DNT	1.1E+02[a]	2.3E+01[a]	2.3E-01[a]	Dermal Contact/ Occupational
2,6-DNT	2.2E+02[a]	2.3E+01[a]	2.3E-01[a]	Dermal Contact/ Occupational
1,3-DNB	2.7E+01	--	--	Soil Ingestion/ Residential
1,2-DNB	1.1E+02	--	--	Soil Ingestion/ Residential
1,4-DNB	1.1E+02	--	--	Soil Ingestion/ Residential
RDX	2.1E+02[a]	1.8E+02[a]	1.8E+00[a]	Dermal Contact/ Occupational
1,3,5-TNB	1.4E+01	--	--	Soil Ingestion/ Residential

-- Not evaluated for carcinogenic effects; no data available.
a. Risk-based soil concentration calculated using an estimated toxicity value for dermal exposure.

5. REFERENCES

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APPENDIX

SUMMARY TABLE OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR
ORDNANCE AREAS (OU 10-05) SOIL CONTAMINATION FOR 2,4,6-TRINITROTOLUENE (TNT)

Exposure	Scenarios					
	Occupational			Residential		
Pathways	Soil concentration		Soil Concentration at HQ = 1 (mg/kg)	Soil Concentration		Soil Concentration at HQ = 1 (mg/kg)
	1E-04 Risk	1E-06 Risk		1E-04 Risk	1E-06 Risk	
Soil Ingestion	1.9E+04	1.9E+02	1.0E+03	2.1E+03	2.1E+01	1.4E+02
Dermal Contact	4.4E+02[a]	4.4E+00[a]	2.6E+01[a]	6.8E+02[a]	6.8E+00[a]	4.7E+01[a]
Inhalation of Fugitive Dust	--	--	2.5E+06[a]	--	--	1.8E+06[a]

-- = Calculation not performed because of no published toxicity value or lack of toxicity data.
a. Soil concentration was calculated using a derived toxicity value.

SUMMARY TABLE OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR
ORDNANCE AREAS (OU 10-05) SOIL CONTAMINATION FOR 2,4-DINITROTOLUENE (2,4-DNT)

Exposure	Scenarios					
	Occupational			Residential		
Pathways	Soil concentration		Soil Concentration at HQ = 1 (mg/kg)	Soil Concentration		Soil Concentration at HQ = 1 (mg/kg)
	1E-04 Risk	1E-06 Risk		1E-04 Risk	1E-06 Risk	
Soil Ingestion	8.4E+02	8.4E+00	4.0E+03[a]	9.4E+01	9.4E-01	5.4E+02[a]
Dermal Contact	2.3E+01[a]	2.3E-01[a]	1.1E+02[a]	3.5E+01[a]	3.5E-01[a]	2.1E+02[a]
Inhalation of Fugitive Dust	--	--	7.7E+06[a]	--	--	5.6E+06[a]

-- = Calculation not performed because of no published toxicity value or lack of toxicity data.
a. Soil concentration was calculated using a derived toxicity value.

SUMMARY TABLE OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR
ORDNANCE AREAS (OU 10-05) SOIL CONTAMINATION FOR 2,6-DINITROTOLUENE (2,6-DNT)

Exposure	Scenarios					
	Occupational			Residential		
Pathways	Soil concentration		Soil Concentration at HQ = 1 (mg/kg)	Soil Concentration		Soil Concentration at HQ = 1 (mg/kg)
	1E-04 Risk	1E-06 Risk		1E-04 Risk	1E-06 Risk	
Soil Ingestion	8.4E+02	8.4E+00	8.0E+03[a]	9.4E+01	9.4E-01	1.1E+03[a]
Dermal Contact	2.3E+01[a]	2.3E-01[a]	2.2E+02[a]	3.5E+01[a]	3.5E-01[a]	4.1E+02[a]
Inhalation of Fugitive Dust	--	--	7.7E+06[a]	--	--	5.6E+06[a]

-- = Calculation not performed because of no published toxicity value or lack of toxicity data.
a. Soil concentration was calculated using a derived toxicity value.

SUMMARY TABLE OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR
ORDNANCE AREAS (OU 10-05) SOIL CONTAMINATION FOR 1,3-DINITROBENZENE (1,3-DNB)

Exposure	Scenarios					
	Occupational			Residential		
Pathways	Soil concentration		Soil Concentration at HQ = 1 (mg/kg)	Soil Concentration		Soil Concentration at HQ = 1 (mg/kg)
	1E-04 Risk	1E-06 Risk		1E-04 Risk	1E-06 Risk	
Soil Ingestion	--	--	2.0E+02	--	--	2.7E+01
Dermal Contact	--	--	1.2E+02[a]	--	--	2.3E+02[a]
Inhalation of Fugitive Dust	--	--	5.2E+06[a]	--	--	3.8E+06[a]

-- = Calculation not performed because of no published toxicity value or lack of toxicity data.
a. Soil concentration was calculated using a derived toxicity value.

SUMMARY TABLE OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR
ORDNANCE AREAS (OU 10-05) SOIL CONTAMINATION FOR 1,2-DINITROBENZENE (1,2-DNB)

Exposure	Scenarios					
	Occupational			Residential		
Pathways	Soil concentration		Soil Concentration at HQ = 1 (mg/kg)	Soil Concentration		Soil Concentration at HQ = 1 (mg/kg)
	1E-04 Risk	1E-06 Risk		1E-04 Risk	1E-06 Risk	
Soil Ingestion	--	--	8.0E+02	--	--	1.1E+02
Dermal Contact	--	--	1.2E+02[a]	--	--	2.3E+02[a]
Inhalation of Fugitive Dust	--	--	5.2E+06[a]	--	--	3.8E+06[a]

-- = Calculation not performed because of no published toxicity value or lack of toxicity data.
a. Soil concentration was calculated using a derived toxicity value.

SUMMARY TABLE OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR
ORDNANCE AREAS (OU 10-05) SOIL CONTAMINATION FOR 1,4-DINITROBENZENE (1,4-DNB)

Exposure	Scenarios					
	Occupational			Residential		
Pathways	Soil concentration		Soil Concentration at HQ = 1 (mg/kg)	Soil Concentration		Soil Concentration at HQ = 1 (mg/kg)
	1E-04 Risk	1E-06 Risk		1E-04 Risk	1E-06 Risk	
Soil Ingestion	--	--	8.0E+02	--	--	1.1E+02
Dermal Contact	--	--	1.2E+02[a]	--	--	2.3E+02[a]
Inhalation of Fugitive Dust	--	--	5.2E+06[a]	--	--	3.8E+06[a]

-- = Calculation not performed because of no published toxicity value or lack of toxicity data.
a. Soil concentration was calculated using a derived toxicity value.

SUMMARY TABLE OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR
ORDNANCE AREAS (OU 10-05) SOIL CONTAMINATION FOR HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE (RDX)

Exposure	Scenarios					
	Occupational			Residential		
Pathways	Soil concentration		Soil Concentration at HQ = 1 (mg/kg)	Soil Concentration		Soil Concentration at HQ = 1 (mg/kg)
	1E-04 Risk	1E-06 Risk		1E-04 Risk	1E-06 Risk	
Soil Ingestion	5.2E+03	5.2E+01	6.0E+03	5.8E+02	5.8E+00	8.1E+02
Dermal Contact	1.8E+02[a]	1.8E+00[a]	2.1E+02[a]	2.7E+02[a]	2.7E+00[a]	3.9E+02[a]
Inhalation of Fugitive Dust	--	--	7.7E+06[a]	--	--	5.6E+06[a]

-- = Calculation not performed because of no published toxicity value or lack of toxicity data.
a. Soil concentration was calculated using a derived toxicity value.

SUMMARY TABLE OF RISK-BASED SOIL SCREENING CONCENTRATIONS FOR
ORDNANCE AREAS (OU 10-05) SOIL CONTAMINATION FOR 1,3,5-TRINITROBENZENE (1,3,5-TNB)

Exposure	Scenarios					
	Occupational			Residential		
Pathways	Soil concentration		Soil Concentration at HQ = 1 (mg/kg)	Soil Concentration		Soil Concentration at HQ = 1 (mg/kg)
	1E-04 Risk	1E-06 Risk		1E-04 Risk	1E-06 Risk	
Soil Ingestion	--	--	1.0E+02	--	--	1.4E+01
Inhalation of Fugitive Dust	--	--	--	--	--	--

-- = Calculation not performed because of no published toxicity value or lack of toxicity data.